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Date of Filing	:	7 MARCH 2003
Application Number	:	200301441-2
Applicant(s) / Proprietor(s) of Patent	:	STMICROELECTRONICS ASIA PACIFIC PTE LTD
Title of Invention	:	A METHOD FOR PROCESSING A DIGIAL VIDEO AUDIO SIGNAL

SHARMAINE WU (Ms)
Assistant Registrar
for REGISTRAR OF PATENTS
SINGAPORE

23 MARCH 2004

PATENTS FORM 1
Patents Act
(Cap. 221)
Patents Rules
Rule 19

INTELLECTUAL PROPERTY OFFICE OF SINGAPORE

REQUEST FOR THE GRANT OF A PATENT UNDER SECTION 25

* denotes mandatory fields

1. YOUR REFERENCE*	1013757PAT/STMicro/MK/FL
2. TITLE OF INVENTION*	A METHOD FOR PROCESSING A DIGIAL VIDEO AUDIO SIGNAL

3. DETAILS OF APPLICANT(S)* (see note 3) Number of applicant(s): 1

(A) Name	**STMicroelectronics Asia Pacific Pte Ltd** (A Private Limited Company Incorporated In The Republic Of Singapore)
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State	
Country	Singapore

[X] For corporate applicant
State of incorporation:
Country of incorporation: Singapore

[ ] For individual applicant
State of residency:
Country of residency:

[ ] For others (please specify in the box provided below)

(B) Name	
Address	
State	
Country	

ACTION

For corporate applicant

State of incorporation

Country of incorporation

For individual applicant

State of residency

Country of residency

For others (please specify in the box provided below)

(C) Name

Address

State

Country

For corporate applicant

State of incorporation

Country of incorporation

For individual applicant

State of residency

Country of residency

For others (please specify in the box provided below)

Further applicants are to be indicated on continuation sheet 1

4. DECLARATION OF PRIORITY (see note 5)

A Country/country designated

File number

Filing Date DD MM YYYY

B Country/country designated

File number

Filing Date DD MM YYYY

Further details are to be indicated on continuation sheet 6

5. INVENTOR(S)* (see note 6)

A The applicant(s) is/are the sole/joint inventor(s) Yes No X

B A statement on Patents Form 8 is/will be furnished Yes [X] No [ ]

6. CLAIMING AN EARLIER FILING DATE UNDER (see note 7)

[ ] section 20(3) [ ] section 26(6) [ ] section 47(4)

Patent application number [ ]

DD MM YYYY

Filing Date [ ]

Please mark with a cross in the relevant checkbox provided below
(Note. Only one checkbox may be crossed.)

[ ] Proceedings under rule 27(1)(a)

DD MM YYYY

Date on which the earlier application was amended [ ]

[ ] Proceedings under rule 27(1)(b)

7. SECTION 14(4)(C) REQUIREMENTS (see note 8)

Invention has been displayed at an international exhibition. Yes [ ] No [X]

8. SECTION 114 REQUIREMENTS (see note 9)

The invention relates to and/or used a micro-organism deposited for the purposes of disclosure in accordance with section 114 with a depository authority under the Budapest Treaty.

Yes [ ] No [X]

9. CHECKLIST*

(A) The application consists of the following number of sheets

i	Request	5	Sheets
ii	Description	13	Sheets
iii.	Claim(s)	2	Sheets
iv.	Drawing(s)	4	Sheets
v.	Abstract (Note: The figure of the drawing, if any, should accompany the abstract)	1	Sheets
Total number of sheets		25	Sheets

(B) The application as filed is accompanied by:

[ ] Priority document(s) [ ] Translation of priority document(s)

[X] Statement of Inventorship & right to grant

[ ] International exhibition certificate

10. DETAILS OF AGENT (see notes 10, 11 and 12)

Name

Firm: DONALDSON & BURKINSHAW

11. ADDRESS FOR SERVICE IN SINGAPORE* (see note 10)

Block/Hse No. | Level No. | Unit No /PO Box: 3667

Street Name

Building Name

Postal Code: 905667

12. NAME, SIGNATURE AND DECLARATION (WHERE APPROPRIATE) OF APPLICANT OR AGENT* (see note 12)
(Note Please cross the box below where appropriate.)

[X] I, the undersigned, do hereby declare that I have been duly authorised to act as representative, for the purposes of this application, on behalf of the applicant(s) named in paragraph 3 herein

Michael S Kraal

Name and Signature

DD MM YYYY: 07-03-2003

NOTES:

1 This form when completed, should be brought or sent to the Registry of Patents together with the rest of the application. Please note that the filing fee should be furnished within the period prescribed

2 The relevant checkboxes as indicated in bold should be marked with a cross where applicable.

3 Enter the name and address of each applicant in the spaces provided in paragraph 3.
Where the applicant is an individual
- Names of individuals should be indicated in full and the surname or family name should be underlined.
-The address of each individual should also be furnished in the space provided.
- The checkbox for "For individual applicant" should be marked with a cross.

Where the applicant is a body corporate
- Bodies corporate should be designated by their corporate name and country of incorporation and, where appropriate, the state of incorporation within that country should be entered where provided.
- The address of the body corporate should also be furnished in the space provided.
- The checkbox for "For corporate applicant" should be marked with a cross.

Where the applicant is a partnership
- *The details of all partners must be provided The name of each partner should be indicated in full and the surname or family* name should be underlined.
- The address of each partner should also be furnished in the space provided.
- The checkbox for "For others" should be marked with a cross and the name and address of the partnership should be indicated in the box provided.

4. In the field for "Country", please refer to the standard list of country codes made available by the Registry of Patents and enter the country code corresponding to the country in question.

5. The declaration of priority in paragraph 4 should state the date of the previous filing, the country in which it was made, and indicate the file number, if available. Where the application relied upon in an International Application or a regional patent application e.g. European patent application, one of the countries designated in that application [being one falling under section 17 of the Patents Act] should be identified and the country should be entered in the space provided.

6. Where the applicant or applicants is/are the sole inventor or the joint inventors, paragraph 5 should be completed by marking with a cross the 'YES' checkbox in the declaration (A) and the 'NO' checkbox in the alternative statement (B) Where this is not the case, the 'NO' checkbox in declaration (A) should be marked with a cross and a statement will be required to be filed on Patents Form 8.

7. When an application is made by virtue of section 20(3), 26(6) or 47(4), the appropriate section should be identified in paragraph 6 and the number of the earlier application or any patent granted thereon identified. Applicants proceeding under section 26(6) should identify which provision in rule 27 they are proceeding under. If the applicants are proceeding under rule 27(1)(a), they should also indicate the date on which the earlier application was amended

8. Where the applicant wishes an earlier disclosure of the invention by him at an International Exhibition to be disregarded in accordance with section 14(4)(c), then the 'YES' checkbox at paragraph 7 should be marked with a cross Otherwise, the 'NO' checkbox should be marked with a cross.

9 Where in disclosing the invention the application refers to one or more micro-organisms deposited with a depository authority under the Budapest Treaty, then the 'YES' checkbox at paragraph 8 should be marked with a cross Otherwise, the 'NO' checkbox should be marked with a cross. Attention is also drawn to the Fourth Schedule of the Patents Rules.

10. Where an agent is appointed, the fields for "DETAILS OF AGENT" and "ADDRESS FOR SERVICE IN SINGAPORE" should be completed and they should be the same as those found in the corresponding Patents Form 41 In the event where no agent is appointed, the field for "ADDRESS FOR SERVICE IN SINGAPORE" should be completed, leaving the field for "DETAILS OF AGENT" blank.

11. In the event where an individual is appointed as an agent, the sub-field "Name" under "DETAILS OF AGENT" must be completed by entering the full name of the individual. The sub-field "Firm" may be left blank. In the event where a partnership/body corporate is appointed as an agent, the sub-field "Firm" under "DETAILS OF AGENT" must be completed by entering the name of the partnership/body corporate. The sub-field "Name" may be left blank

12. Attention is drawn to sections 104 and 105 of the Patents Act, rules 90 and 105 of the Patents Rules, and the Patents (Patent Agents) Rules 2001.

13 Applicants resident in Singapore are reminded that if the Registry of Patents considers that an application contains information the publication of which might be prejudicial to the defence of Singapore or the safety of the public, it may prohibit or restrict its publication or communication. Any person resident in Singapore and wishing to apply for patent protection in other countries must first obtain permission from the Singapore Registry of Patents unless they have already applied for a patent for the same invention in Singapore. In the latter case, no application should be made overseas until at least 2 months after the application has been filed in Singapore, and unless no directions had been issued under section 33 by the Registrar or such directions have been revoked. Attention is drawn to sections 33 and 34 of the Patents Act.

14 If the space provided in the patents form is not enough, the additional information should be entered in the relevant continuation sheet. Please note that the continuation sheets need not be filed with the Registry of Patents if they are not used.

A METHOD FOR PROCESSING A DIGITAL VIDEO AUDIO SIGNAL

Background of the invention

The present invention relates to a method of decoding an audio signal included in a Digital Video (DV) data stream. The DV format is commonly used to store video and audio sourced from domestic camcorders. The data format is adapted to store both data related to the video signal and the audio signal. Both signals are generally decoded separately.

Description of the Prior Art

The audio part of DV data is formatted to include:

- Audio Pre-amble
- 14 Data-Sync blocks, each including:
    - a Sync area of 2 bytes
    - an ID code of 3 bytes
    - a data area of 85 bytes
- Audio Post-amble

The format of the data-sync blocks is shown in Figure 1.

When the audio data is encoded and stored in DV format, audio samples and data are shuffled over different tracks and data-sync blocks within an audio frame. Firstly, audio data is shuffled, and then dummy data is added. The position of the n^{th} audio sample is determined from the equations (1) – (6) which follow:

$$\begin{cases} t_1 = [\lfloor n/3 \rfloor + 2 * (n\%3)]\%T & \text{(CH1)} & (1) \\ t_2 = [\lfloor n/3 \rfloor + 2 * (n\%3)]\%T + T & \text{(CH2)} & (2) \\ s_1 = C_1 + 3 * (n\%3) + \lfloor (n\%K_1)/K_2 \rfloor & & (3) \\ b_1 = C_2 + B * \lfloor n/K_1 \rfloor & \text{(byte 1)} & (4) \\ b'_1 = C_2 + 1 + B * \lfloor n/K_1 \rfloor & \text{(byte 2)} & (5) \\ b''_1 = C_2 + 2 + B * \lfloor n/K_1 \rfloor & \text{(byte3 for 4-ch mode)} & (6) \end{cases}$$

In relation to the above equations, R is the set of all real numbers. Z is the set of all integers (positive and negative). N is the set of all natural numbers. t_1 and t_2 are the track numbers for channel 1 and channel 2 respectively. s_1 is the sync block number and b_1 is the byte position within the DIF block. A DIF (Digital Interface Frame) block is a sub-part of a DV frame. A DV frame includes either 90 or 108 DIF frames depending on whether the system is 525/60 or 625/50. Figure 5 illustrates the relationship between a DV frame and a DIF block, where the dotted box represents a DV frame, while each individual row of data samples represents a DIF block.

With regard to the notation used in this specification, [a,b] indicates a range inclusive of both a and b. (a,b] indicates a range exclusive of a, but inclusive of b. [a,b) indicates a range inclusive of a, but exclusive of b.

If x is a real number ($x \in R$), then $\lfloor x \rfloor$ indicates the largest integer that is $\leq$ x.

$x\%y$ indicates the remainder of the division of x by y, where $x, y \in N$. By number theory, $x\%y \in [0, y)$.

It can be seen from equations (4) – (6) that bytes belonging to the same sample are distributed consecutively within the same DIF block. Samples from different channels but with the same indices have the same sync block number and byte position but different track numbers. The relationship between sync-blocks and tracks is illustrated in Table 1, which shows how they are related to the sample index and the constants T, K_1, K_2 and B.

The coding process involves a shuffling operation which maps from the PCM (Pulse Code Modulation) domain to the DV domain. Figure 2 shows a top level block diagram of the mapping operation, showing how the raw PCM data is mapped on the basis of t_1, t_2, s_1 and b_1 into DV format. Figure 3 shows a more detailed view of the shuffling of particular samples, in which the left hand side shows a PCM frame with data samples $D_0 \ldots D_N$. The dotted rectangle on the right hand side shows a DV frame. For each PCM sample, D_n, its index, n, is used as the input to the shuffling equations (1) to (6) to determine its

corresponding position in the DV frame. That is, $(t_1, s_1, b_1) = f(n) \Rightarrow DV[t_1][s_1][b_1] = PCM[n] = D_n$.

The values T, B, K_1 and K_2 are system dependent and are summarised in the table below, along with the constants C1 and C2.

System		*T*	K_1	K_2	*B*	C_1	C_2
2-ch mode	525/60	5	45	15	2	2	10
	625/50	6	54	18	2	2	10
4-ch mode	525/60	5	45	15	3	2	10
	625/50	6	54	18	3	2	10

Table 1

The numbers in the System column of the above table refer to the number of lines in the video system and the refresh rate. So, 525/60 is a 525 line TV system with a 60Hz refresh rate.

The DV audio signal is decoded to enable the audio to be reproduced by playback equipment, such as a video cassette player. If the shuffled coded data may be represented as $(t_1, t_2, s_1, b_1) = f(n)$, then the reverse mapping f^{-1} may be considered to provide the correct order of data. This concept is shown in Figure 4.

However, this concept is not generally possible in practice, as the shuffling process involves modular and non-linear operations, such as $\lfloor x \rfloor$, which result in a one-to-many reverse relationship. It is therefore not generally possible to easily find a suitable reverse mapping f^{-1}.

Prior art DV audio decoders therefore generally operate in one of two known ways. The first way involves the creation of a Look Up Table (LUT) in which a mapping relationship between received data and the required output data is pre-computed and stored to enable the received data to be re-formatted accordingly.

This method includes the following steps:

- Every element in the table is initialised to –1;
- For every $n \in [0,N]$, compute (t_1, s_1, b_1) using the shuffling equations (1) – (6);
- Store values for n in a LUT with index $[t_1, s_1, b_1]$ i.e. LUT $[t_1]$ $[s_1]$ $[b_1]$ = n;
- For any incoming shuffled data byte, determine its position in the raw PCM data :
    - IF LUT $[t_1]$ $[s_1]$ $[b_1]$ = -1 THEN discard value;
    - ELSE PCM [LUT $[t_1]$ $[s_1]$ $[b_1]$] = DV $[t_1]$ $[s_1]$ $[b_1]$

The major disadvantage of this particular method is the large amount of memory required to store the LUT. Since the constants (T, K_1, K_2 and B) involved in the shuffling equations can be of different values depending on whether it is a 525/60 or 625/50 system, or a 2 or 4-channel system, four separate look-up tables are required. Each LUT is similar in size to a DV frame.

The second method involves receiving and buffering an entire DV audio frame, which is then analysed so that the received data can be decoded on the basis of the analysis.

Using this method, there is no requirement to explicitly determine the reverse mapping f^{-1}, but it has the drawback that an entire DV audio frame has to be buffered or stored before decoding can start. This is because a sample occurring in the very first position of the raw PCM data may be shuffled to a position very late in the DV frame. Therefore, this technique may only be used once a complete DV audio frame is available.

To use this method, values of (t_1, s_1, b_1) are calculated for n = 0 to N. i.e. $(t_1, s_1, b_1) = f(n)$. Then PCM[n] = DV $[t_1]$ $[s_1]$ $[b_1]$

The prior art methods are problematic in that they both require relatively large amounts of memory in order to either store the LUT or buffer the received signal for further analysis. The methods themselves are relatively straightforward to implement, but the memory requirements render them undesirable in practical systems.

Summary of the Present Invention

In a first broad form, the present invention provides method of decoding audio data, encoded in multiple DIF blocks in a Digital Video (DV) data stream, and outputting said audio data as a PCM frame, including the following steps:

(i) fetching a single Digital Interface Frame (DIF) block from the DV data stream;

(ii) de-shuffling a first byte in the single DIF block to determine its index (n) in the PCM frame;

(iii) repeating step (ii) until the last byte in the single DIF block is processed;

(iv) writing the de-shuffled data into the PCM frame for output if the present DIF block is the last in the present DV frame;

(v) repeat steps (i) to (iv).

By needing only a single DIF block in order to de-shuffle the received data, embodiments of the present invention offer advantages over prior art solutions which require receipt of an entire DV frame consisting of many tens of DIF blocks, or storage of large LUTs, before de-shuffling can begin.

Preferably, the index (n) of a particular data sample in the output PCM frame is dependent on parameters of the DV data.

Preferably, the parameters include:

- track number (t)
- sync block number (s)
- byte position within the DIF block (b)

Preferably, for the first DIF block of a new frame, t, s and a DIF block counter are set to zero.

Preferably, s is incremented by 1 each time a new DIF block is received, and is reset to

zero every nine DIF blocks.

Preferably, t is incremented by 1 every nine DIF blocks.

Preferably, the DV data may be encoded to one of a plurality of different video systems, such as 525/60 (2-channel or 4-channel) or 625/50 (2-channel or 4-channel).

Preferably, each different video system may be characterised by several different constants used in the encoding and decoding of data, these constants being :

System		*T*	*K₁*	*K₂*	*B*	*C₁*	*C₂*
2-ch mode	525/60	5	45	15	2	2	10
	625/50	6	54	18	2	2	10
4-ch mode	525/60	5	45	15	3	2	10
	625/50	6	54	18	3	2	10

9. Preferably, the de-shuffling of data in the single DIF block is performed according to the de-shuffling equation:

$$
\begin{aligned}
n &= f^{-1}(t_1, s_1, b_1) \\
&= K_1 x_1 + K_2 x_2 + c \\
&= K_1 (b_1 / B) + K_2 (s_1 \% 3) + (m' * T + t_1 - 2 * \lfloor s_1 / 3 \rfloor) * 3 + \lfloor s_1 / 3 \rfloor
\end{aligned}
$$

$$
\text{where} \begin{cases} \text{if } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) < 0, m' = 1 \\ \text{elseif } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) \geq 0, m' = 0 \end{cases}
$$

where t_1, s_1, b_1 are the track, sync block and byte numbers respectively, included in the single DIF block, and K_1, K_2 and B are constants characterising a particular coding scheme.

In one of the prior art methods, shuffling equations are used for de-shuffling purposes. In this prior method, values of (t_1, s_1, b_1) are calculated for n = 0 to N, i.e. (t_1, s_1, b_1) = f(n), which leads to PCM [n] = DV [t_1] [s_1] [b_1].

It is noted that values of n run sequentially, whereas values of (t_1, s_1, b_1) do not. This means that for a small n, the corresponding DV byte may appear in the very last part of the

frame. This means that an entire DV frame needs to be buffered in this method, resulting in the storage of a large amount of transient data.

By contrast, embodiments of the present invention use a reverse mapping relationship f^{-1} which enables the position in the raw PCM frame to be determined directly for any given data byte in the DV frame.

In a second broad form, the present invention also provides apparatus for performing the method of the first broad form of the invention. The apparatus is preferably a custom Digital Signal Processor (DSP).

Brief Description of the Drawings

For a better understanding of the present invention and to understand how the same may be brought into effect, the invention will now be described by way of example only, with reference to the appended drawings in which:

Figure 1 shows the format of the audio part of a DV data frame;

Figure 2 shows the shuffling of raw PCM data to encode it as part of a DV data stream;

Figure 3 shows how a PCM frame is shuffled according to the shuffling equations to produce DIF blocks within the DV data frame;

Figure 4 shows the de-shuffling of DV data to produce PCM data;

Figure 5 shows how DV data is de-shuffled according to de-shuffling equations and output as PCM data; and

Figure 6 shows a flowchart detailing the steps in the de-shuffling process.

Detailed Description of the Preferred Embodiments

Embodiments of the invention are able to decode a received DV audio stream based on analysis of a single DIF block rather than on an entire audio frame as per the prior art solutions.

In the following description, the following formula is used:

For $\forall m, n \in N$, or in other words, for any m, n is a Natural Number, and

$$n = \lfloor n/m \rfloor * m + n\%m \qquad (7)$$

The constants C_1 and C_2 can be excluded from equations (1) – (6) without any loss of generality. The equations may therefore be re-written as follows, although the byte positions and sync block numbers are now offset.

$$\begin{cases} t_1 = [\lfloor n/3 \rfloor + 2 * (n\%3)]\%T & \text{(CH1)} & (8) \\ t_2 = [\lfloor n/3 \rfloor + 2 * (n\%3)]\%T + T & \text{(CH2)} & (9) \\ s_1 = 3 * (n\%3) + \lfloor (n\%K_1)/K_2 \rfloor & & (10) \\ b_1 = B * \lfloor n/K_1 \rfloor & \text{(byte 1)} & (11) \\ b'_1 = 1 + B * \lfloor n/K_1 \rfloor & \text{(byte 2)} & (12) \\ b''_1 = 2 + B * \lfloor n/K_1 \rfloor & \text{(byte3 for 4-ch mode)} & (13) \end{cases}$$

The various constants which were included in equations (1) to (6) can be excluded at this stage as they are invariant within a particular format of DV data (e.g. 2-channel 525/60). The sync block number and byte positions are effectively offset to absorb C_1 and C_2.

As all data bytes belonging to the same audio sample are distributed consecutively within the same DIF block, (from equations (11)-(13)), once the first byte in a sample is located, the other bytes may be easily located. The following derivation is for channel one and the first data byte only. The other bytes may be found as described from this information.

$$\lfloor (n\%K_1)/K_2 \rfloor = x_2 \tag{14}$$

$$\Rightarrow n\%K_1 = K_2x_2 + c \quad (\mathrm{c} \in \mathrm{Z} \text{ and } 0 \le \mathrm{c} < \mathrm{K}_2) \tag{15}$$

$$\Rightarrow n = K_1x_1 + K_2x_2 + c \tag{16}$$

Where $x_1 = \lfloor n/K_1 \rfloor = b_1/B$ (17)

From equations (14) - (16) and equation (10), it can be seen that:

$$x_2 = s_1\%3 \tag{18}$$

$$c\%3 = n\%3 \tag{19}$$

$$\lfloor s_1/3 \rfloor = n\%3 \tag{20}$$

$$c\%3 = \lfloor s_1/3 \rfloor \tag{21}$$

Equation (16) then yields:

$$\lfloor n/3 \rfloor = \lfloor (K_1x_1)/3 \rfloor + \lfloor (K_2x_2)/3 \rfloor + \lfloor c/3 \rfloor \tag{22}$$

$$t_1 = [\lfloor n/3 \rfloor + 2*(n\%3)]\%T$$

$$\left.\begin{array}{l} \Rightarrow \lfloor n/3 \rfloor = m*T + t_1 - 2*(n\%3) \\ \textit{Equation}\ (14) \end{array}\right\}$$

$$\Rightarrow \lfloor c/3 \rfloor = m^{'}*T + t_1 - 2*(c\%3) = m^{'}*T + t_1 - 2*\lfloor s_1/3 \rfloor$$

$$\text{, where } \mathrm{m}^{'} = m - \lfloor (K_1x_1)/3 \rfloor / T - \lfloor (K_2x_2)/3 \rfloor / T$$

In order to evaluate $\mathrm{m}^{'}$, the constraints of the various parameters may be used as follows:

$$\left.\begin{array}{l} -(T-1) \le m^{'}T \le (T+3) \Rightarrow m^{'} \in \{0,1\} \\ m^{'}*T + t_1 - 2*\lfloor s_1/3 \rfloor = \lfloor c/3 \rfloor \Rightarrow 0 \le m^{'}*T + t_1 - 2*\lfloor s_1/3 \rfloor < T \end{array}\right\} \tag{23}$$

$$\Rightarrow \begin{cases} \text{if } (t_1 - 2*\lfloor s_1/3 \rfloor) < 0, \mathrm{m}^{'} = 1 \\ \text{else if } (t_1 - 2*\lfloor s_1/3 \rfloor) \ge 0, \mathrm{m}^{'} = 0 \end{cases}$$

Equations (16) – (18), (22) and (23) can then be used to define the reverse mapping, f^1 as:

$$\begin{aligned} n &= f^{-1}(t_1, s_1, b_1) \\ &= K_1 x_1 + K_2 x_2 + c \\ &= K_1(b_1 / B) + K_2(s_1 \%3) + (m' * T + t_1 - 2 * \lfloor s_1 / 3 \rfloor) * 3 + \lfloor s_1 / 3 \rfloor \end{aligned} \qquad (24)$$

$$\text{where} \begin{cases} \text{if } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) < 0, \mathrm{m}' = 1 \\ \text{else if } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) \geq 0, \mathrm{m}' = 0 \end{cases}$$

Figure 5 illustrates the 525/60 system. It is apparent that suitable changes may be made in order to adapt the process for other previously mentioned systems such as 625/50.

The process illustrated in Figure 5 includes the following steps:

1. The explicit de-shuffling expression is determined from the shuffling equations. This process to find f^1 from f has already been described, and is performed off-line i.e. it is not necessary to perform the operation in real-time as it may be performed in advance of receipt of the DV data stream.

2. One DIF block at a time is read from the external data stream. The indices of the DV data (t_1, s_1, b_1) are used as the input arguments to the f^1 process. This allows the position n of the appropriate byte in the PCM data to be determined. The same value n is then also used for the subsequent (B-1) byte(s).

3. If the system is operating 2-channel mode, then PCM[n] = DV(t_1, s_1, b_1) $\oplus$ DV(t_1, s_1, b_1+1). If the system is not operating in 2-channel mode, then PCM[n] = DV(t_1, s_1, b_1) $\oplus$ DV(t_1, s_1, b_1+1) $\oplus$ DV(t_1, s_1, b_1+2).

4. Steps 2 and 3 above are repeated until all the DIF blocks in the received DV audio frame are de-shuffled.

5. Post process the de-shuffled data, if necessary, and output as a PCM frame.

A preferred method of performing the de-shuffling operation is to use a suitably programmed DSP (Digital Signal Processor). A single DIF block may be fetched from an external memory to an internal memory of the DSP. The DIF block includes system specific information from which the constants K_1, K_2, T and B may be determined. These constants are used in the subsequent processing.

For the first DIF block of a new frame, the Sync block number s_1, track number t_1, and the DIF block counter are reset to zero. Whenever a new DIF block is received, s_1 is incremented by 1, and is reset to zero every nine DIF blocks. t_1 is then incremented by 1 every nine DIF blocks. Each received DIF block includes 72 data bytes which correspond to 72/B samples.

The shuffling equations reveal that individual data bytes belonging to the same data sample are distributed consecutively in the same DIF block. Making use of this fact, equation 24 is applied to only the first byte of each sample. This first byte, together with the B-1 bytes which follow it are used to determine the PCM sample with index n calculated by the de-shuffling equations.

The pointer to the DIF block data is then incremented by B so that it points to the first byte of the next sample. When all the DIF blocks in a DV frame have been processed as described, the desired number of samples which have been stored in the PCM buffer are written to the external memory, as shown in Figure 6.

In contrast to prior art decoding systems, therefore, embodiments of the present invention do not require an entire DV audio frame to be received before the decoding process can begin. Also, there is no need to prepare and store a large look up table, saving the overhead of providing relatively large amounts of memory.

Embodiments of the invention, using the explicit reverse mapping relationships described previously, are able to directly compile PCM data from incoming DV audio data, requiring only a single DIF block at any one time. The indices t_l, s_l, b_l are all that is required to determine the position of the data in the original PCM frame.

The following table shows the reduction in memory which can be achieved through use of embodiments of the invention with different video standards.

System	Conventional Method (Entire DV Frame Basis)	Embodiments of the Invention (DIF Block Basis)	Memory Reduction Factor
NTSC	10*9 DIF blocks = 10*9*80 bytes = 7200 bytes	1 DIF block = 80 bytes	90
PAL	12*9 DIF blocks = 12*9*80 bytes = 8640 bytes	1 DIF block = 80 bytes	108

The following table illustrates the reduction in different processing operations which can be achieved through use of embodiments of the invention.

Operation	Conventional Method (Entire DV Frame Basis)	Embodiments of the Invention (DIF Block Basis)	Reduction Factor
Modular Operation	3/sample	1/sample	67%
Division	3/sample	2/sample	33%

It can be see that embodiments of the invention are able to provide decoding of DV audio data using significantly less physical memory, and requiring significantly fewer processing operations to achieve the same resultant data as can be achieved by prior art solutions.

In the light of the foregoing description, it will be clear to the skilled man that various modifications may be made within the scope of the invention.

The present invention includes any novel feature or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

CLAIMS

1. A method of decoding audio data, encoded in multiple DIF blocks in a Digital Video (DV) data stream, and outputting said audio data as a PCM frame, including the following steps:

(i) fetching a single Digital Interface Frame (DIF) block from the DV data stream;

(ii) de-shuffling a first byte in the single DIF block to determine its index (n) in the PCM frame;

(iii) repeating step (ii) until the last byte in the single DIF block is processed;

(iv) writing the de-shuffled data into the PCM frame for output if the present DIF block is the last in the present DV frame;

(v) repeat steps (i) to (iv).

2. A method as claimed in claim 1 wherein the index (n) of a particular data sample in the output PCM frame is dependent on parameters of the DV data.

3. A method as claimed in claim 2 wherein the parameters include:

- track number (t)
- sync block number (s)
- byte position within the DIF block (b)

4. A method as claimed in claim 3 wherein for the first DIF block of a new frame, t, s and a DIF block counter are set to zero.

5. A method as claimed in claim 4 wherein s is incremented by 1 each time a new DIF block is received, and is reset to zero every nine DIF blocks.

6. A method as claimed in claim 5 wherein t is incremented by 1 every nine DIF blocks.

7. A method as claimed in any one of the preceding claims wherein the DV data may be encoded to one of a plurality of different video systems, such as 525/60 (2-chamel or 4-

channel) or 625/50 (2-channel or 4-channel).

8. A method according to claim 7 wherein each different video system may be characterised by several different constants used in the encoding and decoding of data, these constants being :

System		T	K_1	K_2	B	C_1	C_2
2-ch mode	525/60	5	45	15	2	2	10
	625/50	6	54	18	2	2	10
4-ch mode	525/60	5	45	15	3	2	10
	625/50	6	54	18	3	2	10

10. A method as claimed in any one of the preceding claims wherein the de-shuffling of data in the single DIF block is performed according to the de-shuffling equation:

$$\begin{aligned} n &= f^{-1}(t_1, s_1, b_1) \\ &= K_1 x_1 + K_2 x_2 + c \\ &= K_1(b_1 / B) + K_2(s_1 \%3) + (m' * T + t_1 - 2 * \lfloor s_1 / 3 \rfloor) * 3 + \lfloor s_1 / 3 \rfloor \end{aligned}$$

$$\text{where} \begin{cases} \text{if } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) < 0, \mathrm{m}' = 1 \\ \text{elseif } (t_1 - 2 * \lfloor s_1 / 3 \rfloor) \geq 0, \mathrm{m}' = 0 \end{cases}$$

where t_1, s_1, b_1 are the track, sync block and byte numbers respectively, included in the single DIF block, and K_1, K_2 and B are constants characterising a particular coding scheme.

11. Apparatus arranged to perform the method of any one of the preceding claims.

12. Apparatus as claimed in claim 11 wherein the apparatus is a custom Digital Signal Processor (DSP).

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ABSTRACT

A METHOD FOR PROCESSING A DIGITAL VIDEO AUDIO SIGNAL

A method is disclosed of decoding audio data, encoded in multiple DIF blocks in a Digital Video (DV) data stream, and outputting said audio data as a PCM frame, including the following steps:

(i) fetching a single Digital Interface Frame (DIF) block from the DV data stream;

(ii) de-shuffling a first byte in the single DIF block to determine its index (n) in the PCM frame;

(iii) repeating step (ii) until the last byte in the single DIF block is processed;

(iv) writing the de-shuffled data into the PCM frame for output if the present DIF block is the last in the present DV frame;

(v) repeat steps (i) to (iv).

Also disclosed is apparatus arranged to perform the method, and de-shuffling equations to perform the de-shuffling of the data.

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Sync blk number	2 Sync Area	3 ID Code	5 AAUX Data	← 72 bytes → Audio Data	8 Inner Parity
2					
3					
4					
:	:	:	:	:	:
8					
9					
10					

Figure 1

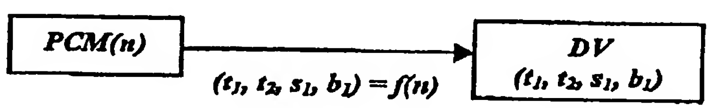

Figure 2

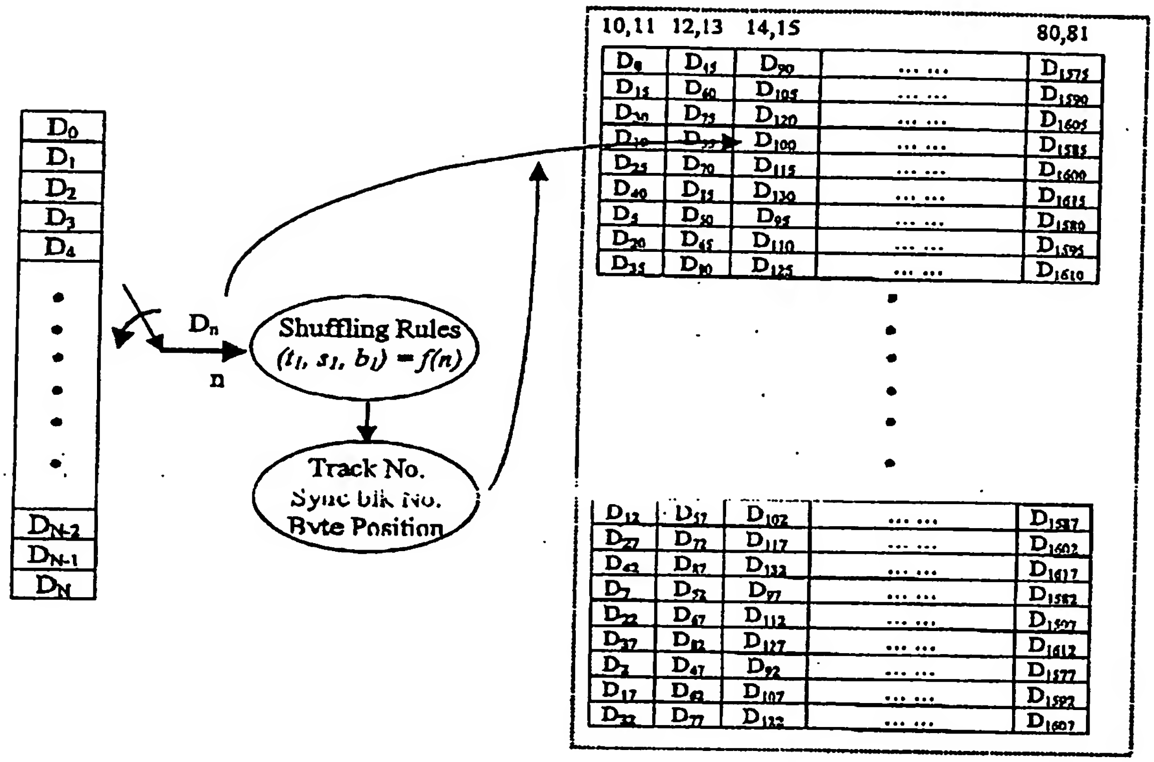

Figure 3

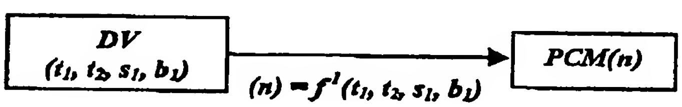

Figure 4

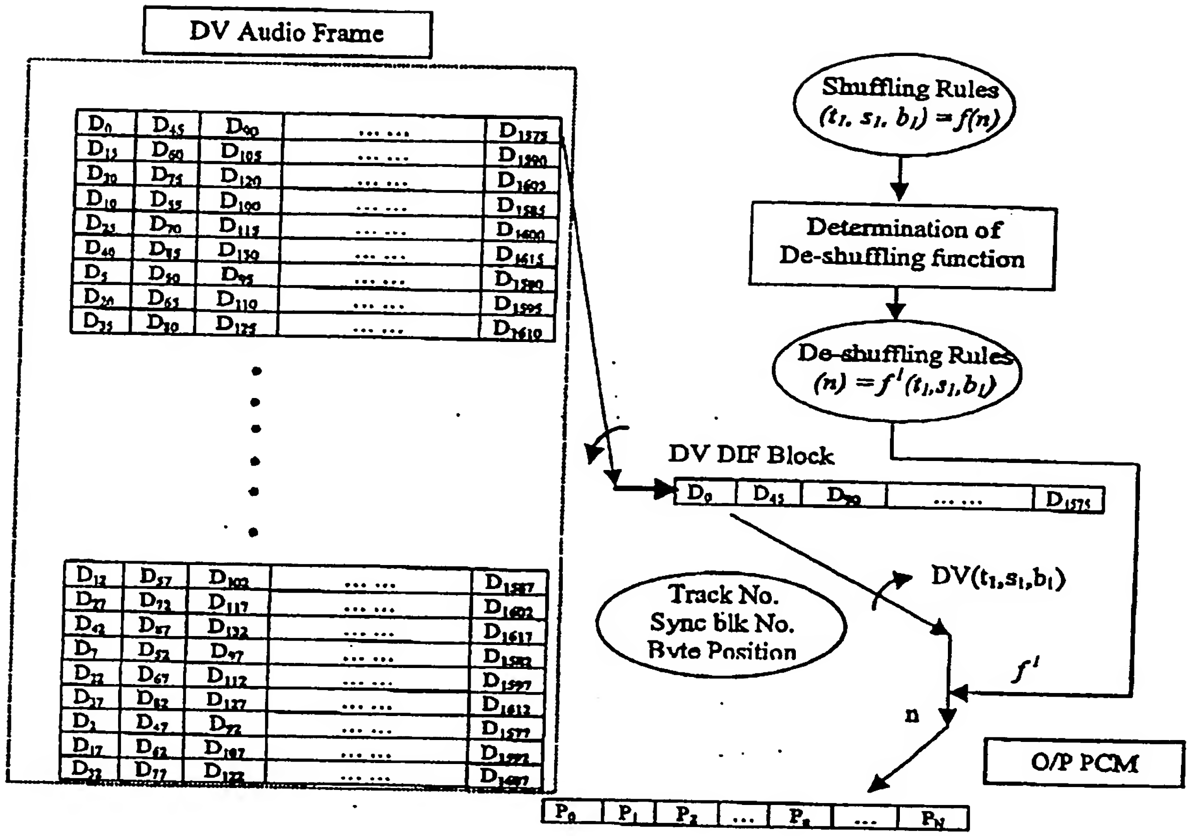
DV Audio Frame
Shuffling Rules
$(t_1, s_1, b_1) = f(n)$
Determination of
De-shuffling function
De-shuffling Rules
$(n) = f^1(t_1, s_1, b_1)$
DV DIF Block
DV(t_1,s_1,b_1)
Track No.
Sync blk No.
Byte Position
f^1
n
O/P PCM

Figure 5

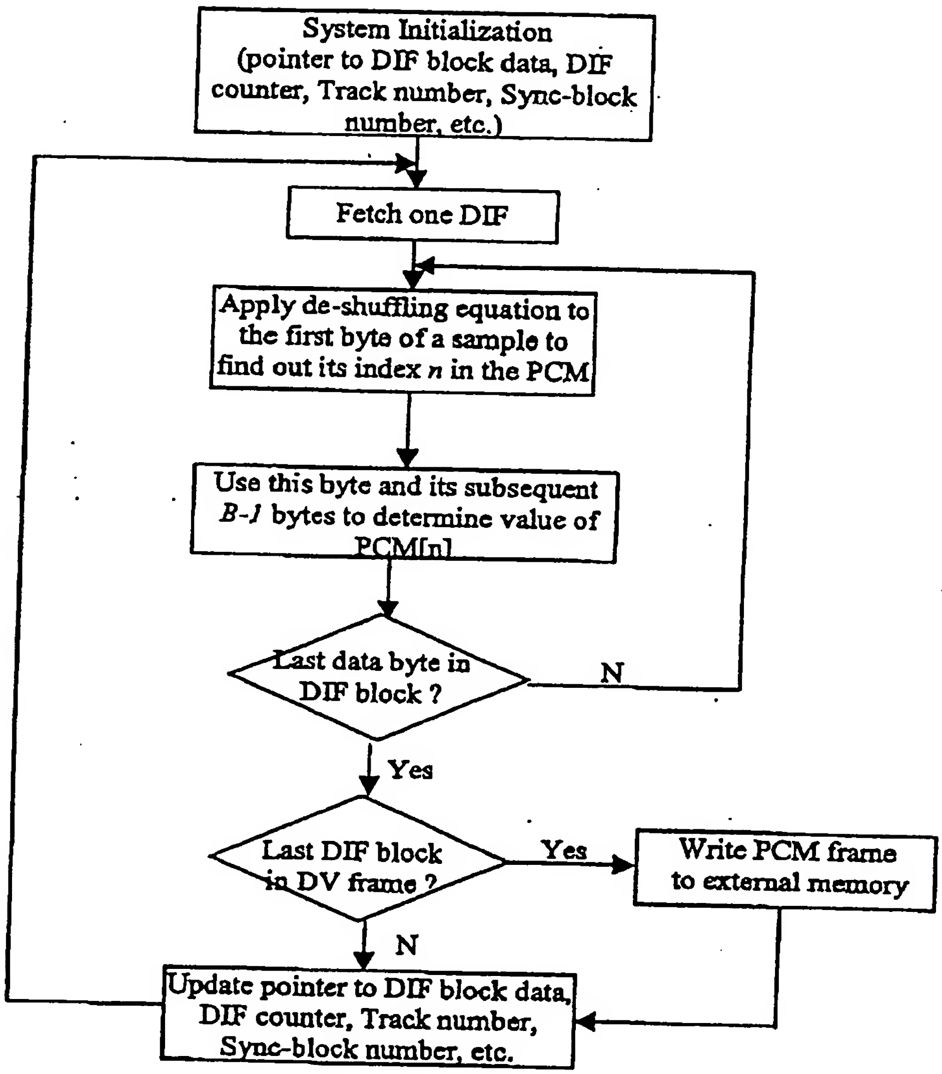
System Initialization (pointer to DIF block data, DIF counter, Track number, Sync-block number, etc.)
Fetch one DIF
Apply de-shuffling equation to the first byte of a sample to find out its index n in the PCM
Use this byte and its subsequent B-1 bytes to determine value of PCM[n]
Last data byte in DIF block ?
N
Yes
Last DIF block in DV frame ?
Yes
Write PCM frame to external memory
N
Update pointer to DIF block data, DIF counter, Track number, Sync-block number, etc.

Figure 6